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IMPORTANT TOMATO INSECTS OF CALIFORNIA

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E. O. ESSIG[1] AND A. E. MICHELBACHER[2]

INTRODUCTION

FOR MANY YEARS it has been known that tomatoes are subject to the attacks of a rather large number of lepidopterous larvae. Important among these are the corn earworm, the tomato pinworm, the potato tuber moth, the tomato worm, the tobacco worm, and many different species of noctuid moths. These pests have always caused considerable damage, but during the past year they have come into great prominence as a result of the discovery by the Microanalytical Division of the Food and Drug Administration, Washington, D. C., of a method of detecting the number of insect parts contained in canned tomato products, and the placing of a tolerance of 15, 25, or 60 parts per 200 cc according to the concentration of the product.[3]

This has caused a demand for control measures which will result in the production of tomatoes as nearly free from worms and worm injury as possible. The object of this report is to set forth much of the information available and to suggest every precaution to avoid the delivery of infested fruit to the packers and to the market.

CORN EARWORM

LIFE HISTORY

The corn earworm,[4] *Heliothis obsoleta* (Fab.), like all other lepidopterous insects, passes through four distinct stages: egg, larva, pupa, and adult. The length of time spent in any one period is markedly influenced by weather conditions. The insect usually produces several generations each year, the count decreasing as one passes northward. A point is reached where winter temperatures are so severe that the overwintering pupae are killed and such areas become infested by migrations of the adults northward. Numerous workers have observed that few pupae are

[1] Professor of Entomology and Entomologist in the Experiment Station.

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[3] See: "Insect Parts in Prepared Tomato Products," pages 33 to 36.

[4] Because *Heliothis obsoleta* (Fab.) is destructive to a great many cultivated plants, it has come to be known by such common names as corn earworm, cotton bollworm, tobacco worm, and tomato worm. In this paper, although it deals with tomatoes, the insect will be referred to by the generally accepted name, the corn earworm.

able to survive the winters in states north of the Ohio River. In California there are no less than three generations; the winter is passed in the pupal stage 2 to 10 inches beneath the soil surface, the overwintering moths emerging from the pupae during the period from April through June.

The adults (fig. 1) have a wing spread of about 1½ inches, and are faun-colored with darker spots on the fore wings and a brown margin

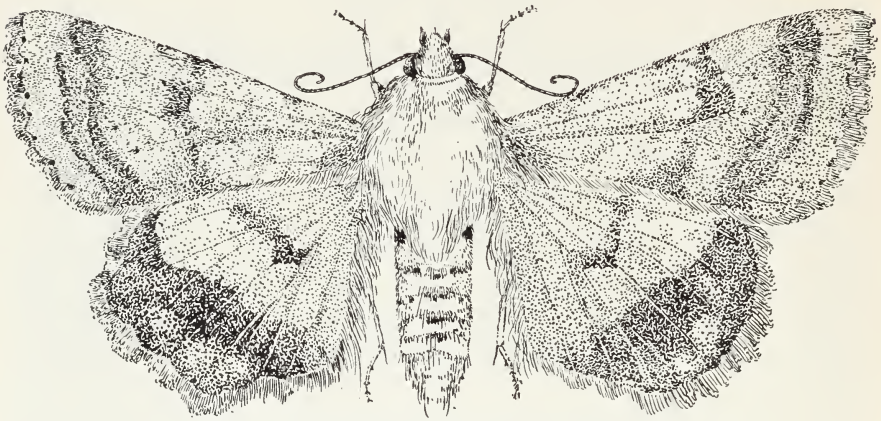


Fig. 1.—The adult moth of the corn earworm.

and transverse brown band on each hind wing. The moths mate soon after emergence and may live for a period of about two weeks or longer. Egg laying begins about 3 days after the adult emerges and continues until death. The number of eggs laid by a single female varies from about 500 to 3,000. They are deposited, usually singly, on various parts of the host plant. The eggs (fig. 2*A*) are round, somewhat flattened, white or pale yellow, and longitudinally ribbed with fine lines. During warm weather they hatch in 3 or 4 days.

The larvae cast their skins about five times, and under favorable conditions may reach maturity in about two weeks. When full-grown they are about 1½ inches in length, show a great variation in color (fig. 2*B*) which ranges from a pale green to almost black, and may be marked with stripes of pink, yellow, brown, or other colors. The caterpillars are very cannibalistic and where two meet the larger one is usually victorious. On completing their development, they burrow into the soil and construct pupal cases a few inches below the surface. From these cells they build tunnels for the emergence of the adults. Larvae of the overwintering brood generally pupate deeper in the soil than those of the summer broods. The pupae (fig. 2*C*) vary from dark amber to chestnut-brown and are about ¾ inch in length. The duration of the

pupal period is two to three weeks during the summer. Apparently by the middle of September, or even before, many of the larvae that pupate are overwintering forms.

HOST RANGE

The corn earworm has an extended host range which includes many kinds of domesticated and wild plants. Practically all cultivated food plants are eaten, and some of them are severely injured. Besides various

Fig. 2.—The corn earworm. *A*, Eggs on tomato (courtesy of F. H. Wymore); *B*, full-grown caterpillars; *C*, pupae or chrysalids removed from the soil.

weeds, the host range includes vegetables, field crops, flowering garden plants, and deciduous and citrus fruits. In all, more than a hundred kinds of plants are devoured by it. It is particularly important as a pest of corn, cotton, tomatoes, and tobacco.

DESTRUCTIVENESS

The corn earworm may cause serious losses to the tomato grower, and at times destroys as much as 50 per cent of the crop in many localities. The most common type of injury is that done to the fruit. The larvae apparently prefer to enter the fruit at the stem, or calyx, end. Here they may continue development, yet from all outward indications the tomatoes may be perfectly sound. Often this type of damage is not observed until the harvester, picking the fruit, notes that it is easily parted from the vine. The examination of the calyx will often reveal the nearly mature larva (fig. 3*A*), and if such a tomato is halved (fig. 3*B*), it will be seen that much of the interior of the fruit has been eaten, leaving a mass of excreta which is indeed unappetizing. Often the worm is hidden deep in the fruit and is not disclosed until the tomato is cut open. If such an infested fruit is not picked, it will shortly fall from the vine.

During the earlier stages of attack by the larvae the injury is even more difficult to detect. The damage caused by a very small larva is almost sure to be overlooked, and not infrequently large worms are missed by the picker. Since such fruits appear perfect, the infestation can only be noted by examining the calyx carefully. In this type of injury coring the fruit in the cannery will completely remove the worm

Fig. 3.—Corn-earworm damage to tomatoes. *A*, Advanced injury of the calyx, or stem, end with caterpillar in burrow; *B*, tomato cut in half to show the internal destruction caused by the caterpillar.

and its work. A tomato may be infested by a fairly large larva and still the damage may not show up. Usually the presence of such a worm is indicated by some sort of blemish on the exterior of the fruit.

It is not uncommon for larvae to complete their development in single fruits, although often they feed for awhile on one fruit and then pass to another, attacking a tomato at any point. Frequently they eat from one fruit into another, and if there is a cluster, they may burrow through one to others, where they usually feed on the surface. Sometimes they may begin eating into a tomato, and for some reason quit and enter another fruit, as is shown in figure 4*B*.[5] Frequently small, green fruits are so injured that their development is markedly retarded and they fail to size.

A survey of the tomato-growing section of central California during the 1935 season revealed the fact that the corn-earworm infestation was irregular, and the number of infested fruits varied considerably in the same field. In order to express the exact crop loss it would be necessary to check carefully the damaged fruit at each picking and then compute the weighted loss for the whole crop. In some fields the most injury

[5] Similar injuries may be caused by armyworms which usually feed on undersides of the fruits resting on the ground.

appeared on the fruits of the first four pickings, the later ones giving every indication that the infestation would show a rather rapid decline. Many fields were surveyed twice, and no marked increase was noted. The information obtained for central California, summarized in table 1, shows that the area of greatest infestation was about San Jose, while the smallest was in the southern portion of the Santa Clara Valley. A

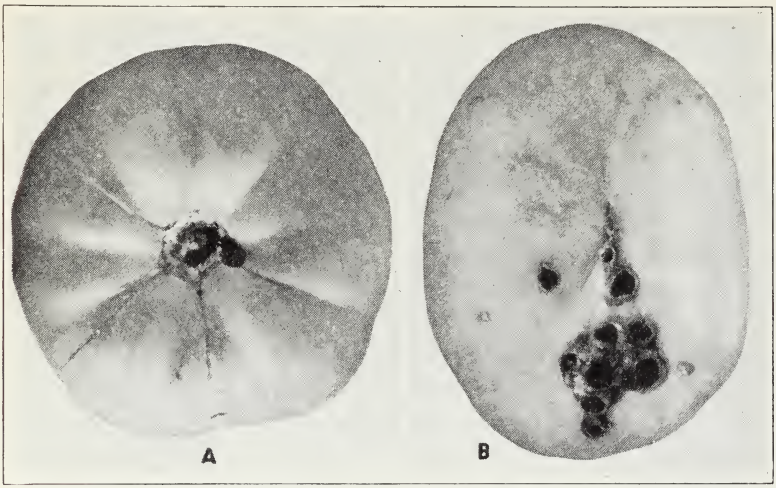


Fig. 4.—Corn-earworm damage to tomatoes. *A*, The calyx removed to show the entrance to the burrow of the caterpillar; *B*, a fruit showing a number of entrances to burrows.

third survey would have been of value, but was impossible because of the early killing frost which occurred on October 24. It would probably have shown a decline in the amount of injury because some fields showed a high primary infestation, but after the wormy tomatoes were removed, the amount of damage decreased rapidly, and the relatively low level of worminess might have continued.

During the latter part of October, 1935, a survey of the tomato-growing section of southern California, extending from San Luis Obispo to San Diego, was made by the junior author and a member of the laboratory of the United States Department of Agriculture Bureau of Entomology and Plant Quarantine at Alhambra. Over much of the area most of the tomatoes had already been picked, but in some regions harvest was at its peak. At the time the survey was made the corn-earworm infestation was rather light. In some fields examined the growers reported that the earlier pickings of tomatoes showed considerably more worminess, which the inspection indicated was true. These observations are in agreement with many made in the central portion of the state. Possibly as winter approaches, the insect becomes less active, and the injury to the

TABLE 1

SUMMARY BY AREAS OF THE 1935 SURVEY OF CORN-EARWORM INFESTATION IN CENTRAL CALIFORNIA

Location by area	Date of survey	Number of fields surveyed	Total number of fruits examined	Range in infestation, per cent	Average per cent infestation
San Lorenzo to Irvington	Sept. 12	8	2,100	4.66–14.00	8.45
	Oct. 7	13	4,800	4.00–18.70	9.97
San Jose	Sept. 18	7	2,300	8.70–42.70	22.17
	Oct. 8	9	3,850	7.70–27.20	16.46
Southern portion of Santa Clara Valley	Sept. 23, Sept. 24	20	6,600	1.00– 6.60	3.11
	Oct. 30, Oct. 31	25	9,950	0.50– 8.57	3.00
Walnut Creek to Pleasanton	Sept. 20	10	3,200	1.00–15.00	6.22
	Oct. 15	16	7,150	2.75–20.75	8.50
Extreme northwest portion of San Joaquin Valley	Sept. 27, Oct. 3	17	7,800	0.75–25.00	8.29
	Nov. 5	10	4,600	2.75–20.50	8.12
Salinas	Sept. 25	7	2,300	0.00– 8.60	4.00

TABLE 2

SUMMARY BY COUNTIES OF THE 1935 SURVEY OF CORN-EARWORM INFESTATION IN SOUTHERN CALIFORNIA

Location by county	Date of survey	Number of fields surveyed	Total number of fruits examined	Range in infestation, per cent	Average per cent infestation
San Diego	Oct. 18, Oct. 20	11	4,200	0.75– 6.50	2.56
Orange	Oct. 20	8	3,600	1.75–17.10	6.74
Riverside	Oct. 18, Oct. 23	7	2,400	1.25– 4.00	2.40
San Bernardino	Oct. 23	4	1,300	1.00– 2.00	1.50
Los Angeles	Oct. 20, Oct. 21	9	3,800	1.25– 8.50	2.49
Ventura	Oct. 21, Oct. 22	17	7,400	0.00–20.00	6.38
Santa Barbara*	Oct. 26	6	2,200	6.80–20.60	15.70
San Luis Obispo	Oct. 26	2	500	4.50–10.60	12.00

* All fruit was being picked for green shipment. Only ripe or nearly ripe fruit examined, and this probably accounts for the high percentage of infestation.

crop decreases. The largest infestations in southern California were found in Ventura County and at Santa Maria, Santa Barbara County. In some fields where tomatoes were harvested green for shipment, the percentage of worm-injured fruit as determined by us may have exceeded the general average because our figures were based on ripe or nearly ripe fruit, which appeared to be more heavily infested than the green fruit of like size. The information is summarized in table 2.

CONTROL

Many measures have been attempted in the control of the corn earworm. Some of these have proved beneficial while others have produced poor or negative results.

Since the insect is so widely distributed and such a general feeder, there are many factors influencing it which require much study. For instance, the corn earworm was not a serious pest in vast areas of California during the 1935 season. A knowledge of the exact conditions that limited its activity in these places may lead to the control of the insect throughout the entire tomato-growing sections of the state. The factors, other than chemical control, are given below.

Cultural Methods.—Since the pupae of the corn earworm occur in the soil, some of them may be killed by exposure to the rigors of climate and to their natural enemies by thorough fall plowing. Cultivation also destroys weeds that serve as hosts for the larvae, and land that is to be planted to tomatoes should be sufficiently worked to keep down all weeds.

Relation of Tomatoes to Other Host Crops and Weeds.—This very important relation can be considered from many angles. A more thorough understanding of the preference-host sequence of the corn earworm and the relative attractiveness of various stages in the growth of the different crops would be of great value. A survey of the literature has given strong evidence that plants are most attractive during the flowering and fruiting stages. Apparently the moths prefer the bloom to the fruit. Although the corn earworm may build up on other crops and on weeds as these are harvested or begin to dry up, the pest may migrate to tomatoes, since this crop is one of the latest to mature. It is quite possible that the tomatoes are more attractive when they are in bloom and setting fruit than is any other crop growing at that time.

Since the corn earworm shows host preference much work has been done in many places by using trap crops, but the results reported have not been consistent. Corn, especially sweet corn, has often been recommended for this purpose, but most investigators point out certain extra precautions that should be observed. Morrill[6] states that the best results

[6] Morrill, A. W. The use of corn as a trap crop for the cotton bollworm. Arizona Agr. Col. Cir. 30:1–10. 1920.

are obtained where corn attains the silking stage, and Ballard[7] comments that corn is a good trap crop, but it should not be allowed to stand until the silk has dried up for it then simply becomes a means of attracting moths into the crop to be protected. He adds that to insure protection during the critical period, corn should be planted at intervals. In South Africa[8] oviposition of the moths of the corn earworm was found to be very closely associated with the period of bud and flower production, and in the case of corn egg laying in quantity, the peak of which lasted only two or three weeks, was found to begin when the tassels were extruding and before the silks were abundant. This information is at variance with the widely accepted view that the eggs are laid on the plant during much of its growth and most heavily during the silking period. Phillips and Barber[9] found that the moths preferred to oviposit on the moist silk of corn, which reached its greatest attractiveness on the third day after its appearance.

Marcovitch and Robert[10] reviewed the subject of trap crops affecting tomatoes, and by experiments showed that corn planted among tomatoes did not give adequate protection in controlling the corn earworm. In Australia, an investigator[11] reports that corn might be grown as a trap crop among tomatoes, but that it should be taken out and used for fodder as soon as the silking stage has been reached. Another investigator[12] also recommended interplanting tomato fields with two plantings of late corn at intervals of two weeks so that fresh silk would be available to the moths at the time the tomato fruit was setting. As soon as the silk withers, the worms on the corn should be destroyed by removing the ears.

From the above discussion it is evident that plants are probably most attractive to the egg-laying moths during the flowering period, and succulent growth is preferred. It also appears that the trap crop should not be interplanted with the crop to be protected, and for best results should be harvested before it becomes mature. The trap crop should be planted at intervals of time to insure that stage of growth most sought

[7] Ballard, E. The maize grub pest; a suggestion for cotton farmers. Queensland Agr. Jour. (Ser. 2) 24(2):146–47. 1925.

[8] Parsons, F. S., and G. C. Ullyett. Investigations on the American and red bollworms of cotton. Empire Cotton Growing Corp. [London] Exp. Sta. Repts. 1932–1933:152–56. 1934.

[9] Phillips, W. J., and G. W. Barber. Egg-laying habits and fate of eggs of the corn earworm moth and factors affecting them. Virginia Agr. Exp. Sta. Tech. Bul. 47:1–14. 1933.

[10] Marcovitch, S., and S. A. Robert. The corn earworm on tomato. Tennessee Agr. Exp. Sta. Bul. 133:1–14. 1925.

[11] Newman, L. J. Climbing cut-worm or tomato moth (*Chloridea obsoleta*). Jour. Dept. Agr. West. Australia (ser. 2) 5(4):423–26. 1928.

[12] Loomis, W. E. Tomatoes for the canning factory. Arkansas Agr. Col. Ext. Cir. 224:1–3. 1932.

by the egg-laying moth during the period the tomato crop is to be protected. Sweet corn appears to be the most attractive trap crop, and should be planted in solid blocks adjacent to the tomatoes.

Resistant Varieties of Tomatoes.—Such varieties have not been investigated to any extent. It has been found that those varieties of tomatoes which produced the most abundant and conspicuous blossoms were consistently the most heavily infested with the larvae of the corn earworm. Some California farmers believe that the pear-shaped tomatoes are less seriously injured than the standard varieties.

Planting Date.—It may be possible that the time of planting tomatoes influences the amount of infestation, but no exact data treating this phase of the subject are available at this time.

Parasites.—The corn earworm is subject to the attack of many parasites and predators which influence population trends and may aid in control. In some localities where environmental factors are extremely favorable the natural enemies may possibly build up in sufficient numbers to check satisfactorily the corn earworm late in the season.

CHEMICAL CONTROL

The survey during the 1935 season showed that after harvest was advanced usually no increase in the infestation occurred, and in many fields there was actually a decrease, which indicated that early control measures were sufficient. As the larvae reach maturity in the fall (middle of September on) and pass into the overwintering pupal stage, the adult population diminishes accordingly.

Sprays and Dusts.—The proper and timely applications of sprays or dusts will reduce corn-earworm injury. This is possible because the newly hatched larvae may feed on the leaves and succulent growth before entering the tomato fruit.

To insure protection to the crop it is necessary to apply the insecticides thoroughly before the caterpillar gains entrance into the fruit. Although a number of insecticides have been used, lead arsenate and calcium arsenate are most frequently recommended. They may also be used in combination with fungicides with good results.

Sprays consisting of lead arsenate and in some cases in combination with bordeaux mixture have been used with varying degrees of success by numerous investigators, and calcium arsenate has been recommended as a dust by others.

From the review of the literature it is evident that sprays and dusts have helped in checking corn-earworm damage. Best results are obtained by applying the materials early in the season when the vines are setting fruit. In most cases a number of sprayings or dustings are necessary for

the best protection. The interval between applications should be from 10 to 14 days and should cease several weeks before the fruit is ready for harvest. The insecticides most used are lead arsenate and calcium arsenate, which are often combined with fungicides.

Many California tomato fields were not treated with insecticides. In the localities where control measures were attempted, dusts were used. In central California only about one-fourth, while in the southern part, considerably more than one-half of the fields received treatment. Calcium arsenate and lead arsenate were chiefly used with lesser amounts of sodium and barium fluosilicates. Information obtained from the growers showed that most fields were dusted only once after the fruit set, although in some fields several applications were made. While dusting appeared to be beneficial, there were some treated fields where little control was effected. Of the dusts, calcium arsenate seemed to be the most effective, but not enough data were obtained to make a definite statement concerning the efficacy of the fluosilicates.[13] Because of the abundance of and necessity for controlling the hornworms, *Protoparce* spp., in the interior valleys, more fields were dusted there than near the coast. The evidence indicated that the greatest infestations of the corn earworm occurred on the first few pickings, and to check its injury the dust should be applied at about the time the fruit is setting. This agrees with the observations made by most workers. Fields should be kept under careful observation and dusted as soon as the young larvae appear. There is evidence that a single application will probably suffice where the initial infestation is light. Later dusting may also be necessary at the time the fruit begins to color. Beyond this point it is not advisable to apply arsenicals or fluosilicates because of the residue problem.

Pending further study the following recommendations are suggested: Where calcium arsenate is used, it may be applied undiluted at the rate of 10 to 15 pounds per acre. Lead arsenate should be diluted with lime in the proportion of 1 to 1 and applied at the rate of 10 to 20 pounds per acre. The fluosilicate dust or synthetic cryolite should be diluted to from 40 to 60 per cent and according to the size of the plants applied at the rate of 20 to 30 pounds per acre.

Derris.—In order to avoid the residue problem, a few growers used a derris dust. In places it was the only material applied, while in others it followed an application of an arsenical or fluosilicate dust. Where used alone, we were unable to detect any worth-while protection, but since so few fields were dusted and the observations so limited, we are

[13] Before calcium arsenate or the fluosilicates are applied to tomatoes, information should be ascertained locally, if possible, concerning the effects of these particular insecticides on the tomato plants, since in some localities rather severe injuries have followed their use.

not in a position to judge its effectiveness. Roney and Thomas[14] reported derris as being very effective against the corn earworm for periods of one to three weeks and stated that applications should begin when the worms first appear if best results are desired. Kadow and Shropshire[15] also reported derris dust as being effective. Their experiments indicated that heavy applications of derris dust containing 0.5 per cent of rotenone will control corn earworm on tomato plants if applied before the infestation becomes heavy. They stated that the dust acts chiefly as a contact poison against the newly hatched worms, but is not very effective against worms that are half grown or larger. Headlee[16] tested derris against a number of insects and found that the corn earworm was not affected. He found that it was able to withstand large dosages of derris when taken internally, and the caterpillar could be rolled in ground derris and yet be apparently unhurt. His studies showed that the lack of response was due to the failure of the derris extract to get into the tissue of the caterpillar, for the insect yields to derris extract hypodermically applied. Huckett and Hervey[17] also called attention to the fact that neither derris nor cubé were satisfactory against the corn earworm. Walker and Anderson[18] stated that derris and pyrethrum dusts had practically no effect on the corn earworm. Hervey and Palm[19] noted the fact that derris deteriorates rapidly on exposure to light and air, and this might prove to be very undesirable since in our opinion a suitable dust for the corn earworm should remain effective over a period of several weeks. There are derris products which show different degrees of stability, and several of these will be thoroughly tested during the coming season.

Various kinds of poison baits have been used against the larvae of the corn earworm, but their use has been so limited as not to warrant comment here. In the Salinas Valley baits have been used in the lettuce fields, but we have no data concerning their effectiveness. Apparently a suitable bait might be used in gathering information on moth activity, and such

[14] Roney, J. N., and F. L. Thomas. Arsenical substitutes for controlling vegetable insects. Jour. Econ. Ent. 28(3):615–17. 1935.

[15] Kadow, K. J., and L. H. Shropshire. Tomato diseases and insect pests. Illinois Agr. Exp. Sta. Cir. 428:1–36. 1935.

[16] Headlee, T. J. Derris as an arsenical substitute on vegetables. Jour. Econ. Ent. 28(3):605–7. 1935.

[17] Huckett, H. C., and G. E. R. Hervey. Recent developments in the use of arsenical substitutes for vegetable pest control in New York. Jour. Econ Ent. 28(3):602–3. 1935.

[18] Walker, H. G., and L. D. Anderson. Summary of results obtained with arsenical substitutes for the control of vegetable crop insects at the Virginia Truck Experiment Station. Jour. Econ. Ent. 28(3):603–5. 1935.

[19] Hervey, G. E. R., and C. E. Palm. Non-arsenical dust for cauliflower worm control in western New York. New York State Agr. Exp. Sta. (Geneva) Bul. 640:1–17. 1934.

data might be of value in timing the application of dusts or sprays. This phase of the subject will be investigated.

Considerable work has been done with attrahents for the adult corn earworm but with negative results.

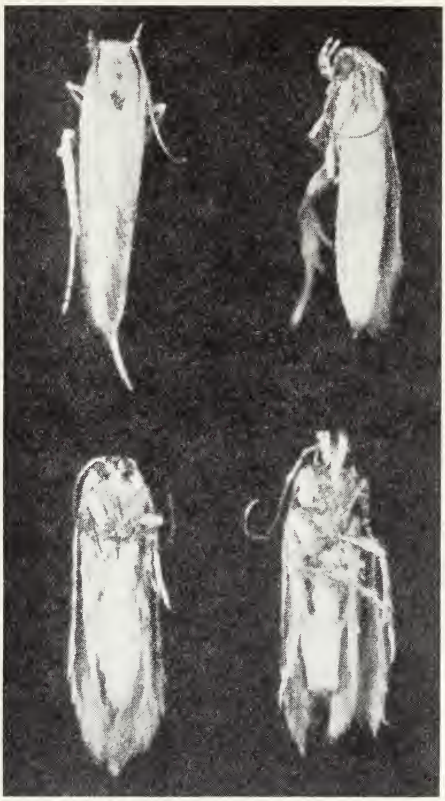


Fig. 5.—Dorsal and ventral views of the tomato pinworm moth: male, right; female, left. (After Campbell and Elmore, courtesy of California State Department of Agriculture.)

TOMATO PINWORM

LIFE HISTORY

The tomato pinworm, *Gnorimoschema lycopersicella* Busck, passes through four distinct stages. There are several generations a year, and the insect hibernates and passes through periods of low temperatures in the pupal stage. The eggs[20] are very small, white, and nearly round, and

[20] Thomas, C. A. Observations on the tomato pinworm (*Gnorimoschema lycopersicella* Busck) and the egg plant leaf miner (*G. glochinella* Zeller) in Pennsylvania. Jour. Econ. Ent. 26(1):137–43. 1933.

are laid on the leaves, stems, flower buds, or on the fruit. The adults (fig. 5) are described as small gray moths about ¼ inch long, and in appearance very much like the potato tuber moth but smaller. The small larvae are described as pale with dark heads, while the older larvae (fig. 6) are green with purplish markings. The mature larvae are about ¼ inch in length and at a glance appear grayish purple. This dark color

Fig. 6.—The pupae and larvae of the tomato pinworm. (After Campbell and Elmore, courtesy of California State Department of Agriculture.)

serves at once to distinguish them from the larger, lighter-colored larvae of the potato tuber moth. Table 3 summarizes the data concerning the life history of the tomato pinworm.

The larvae may complete their development either on the foliage or in the fruit, and pupation may occur in a folded leaf or in the surface soil.

HOST RANGE

The tomato is the most important host plant of the tomato pinworm. Other hosts are potato, nightshade (*Solanum xantii* Gray), and horse nettle (*S. carolinense* L.). As this insect is further studied, the host range will probably be greatly expanded.

DESTRUCTIVENESS

The tomato pinworm is one of the most serious pests of the tomato in California. Although it does greatest damage to the fruit, the vines are also attacked. During the 1935 season, fields in which the amount of infested fruit exceeded 50 per cent were observed in southern California.

Such fields had to be abandoned. Attention has been called to serious damage to tomatoes by this insect in the Imperial Valley,[21] while Campbell and Elmore[22] reported the pinworm as being a serious pest in other parts of southern California. They also pointed out that in several fields infestation was so severe that the fields had to be abandoned without picking a single fruit. They reported that the average loss (summer and

TABLE 3

SUMMARY OF LIFE-HISTORY DATA ON THE TOMATO PINWORM IN CALIFORNIA*

Stage	Length of time in various stages		
	Minimum, days	Maximum, days	Average, days
Incubation	4	30	8.9
Leaf-mining	5	24	11.5
Leaf-folding	3	17	9.5
Prepupa	1	22	6.9
Pupa	15	52	30.2
Total, egg to adult	28	145	67.0
Adult male	1	26	10.3
Adult female	2	38	13.8
Length of egg-laying period	1	20	5.9

* Data from: Campbell, R. E., and J. C. Elmore. The tomato pinworm. California State Dept. Agr. Mo. Bul. **24** (3): 306. 1935.

fall, 1934) in San Diego and Orange counties was 20 to 40 per cent of the crop, while in Los Angeles and Ventura counties, it ranged from 10 to 30 per cent.

To our knowledge the pinworm has not seriously attacked tomatoes in California outside the southern area. It is known to occur in the central and northern parts of the state, for larvae of this pest were collected on *Solanum xantii* Gray at Phoenix Lake, Marin County, and they were also taken in Kern County on tomatoes and potatoes. Since the tomato pinworm has only proved to be a serious pest of tomatoes in recent years, it would be unsafe to predict that it has completely dispersed over the entire geographical area in which it is likely to be destructive. We are unable as yet to say whether or not the moth will become a serious pest in central and northern California.

[21] Morrill, A. W. Commercial entomology on the west coast of Mexico. Jour. Econ. Ent. 18(5):707–16. 1925.

[22] Campbell, R. E., and J. C. Elmore. Damage to tomatoes in southern California by the tomato pin worm and the potato tuber moth. California State Dept. Agr. Mo. Bul. 20(7):458–60. 1931. Also: The tomato pinworm. California State Dept. Agr. Mo. Bul. 24(3):301–9. 1935.

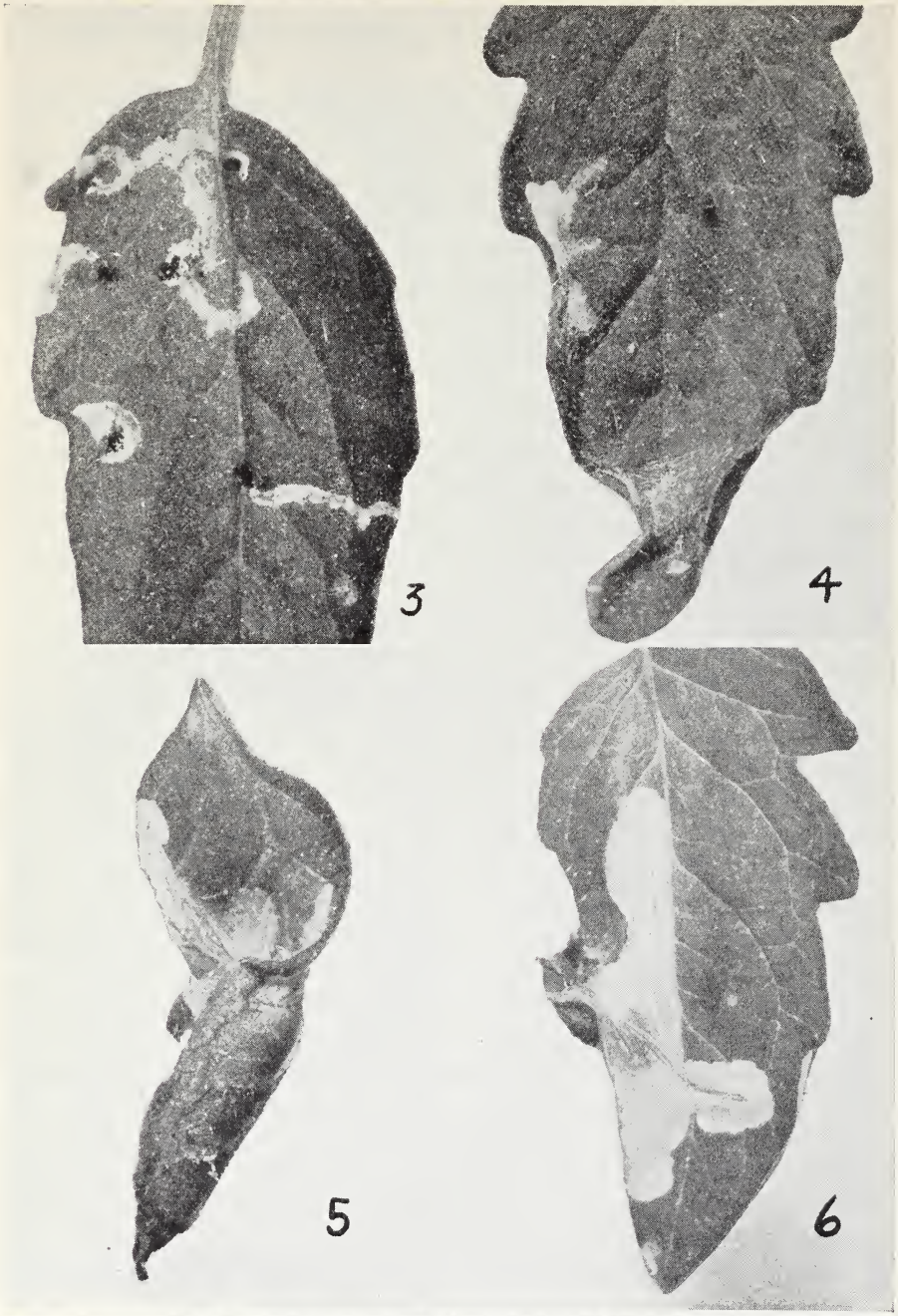


Fig. 7.—*3*, Work of tomato pinworm, 4 days old. *4* and *5*, Folding of leaf tip or leaf by larva which has left its burrow. *6*, Leaf after pinworm has left plant to pupate. Note undisturbed epidermal layers. (Courtesy of California State Dept. Agr.)

Concerning the pinworm attacking foliage, Campbell and Elmore[23] stated:

The larvae on hatching bore into the leaf and eat out an irregular spot or tunnel between the two leaf surfaces (fig. 7, *3*). The blotched leaf mine is characteristic and quite different from the tortuous mine of dipterous miners. The larvae then leave the mine and roll or fold an edge of a leaf or a whole leaf (fig. 7, *4* to *6*), and within this fold feeding continues. Several such folds may be made by a single larva.

The larvae generally enter the calyx of the fruit, and their presence is often unnoticed until the fruit is picked. Even then a careful inspection is necessary to detect the injury (fig. 8). This is particularly true if the larvae are small. They confine their feeding to the core and the fleshy portions that radiate from it. When first picked, the entrance to the burrows may be open, but after the fruit is allowed to stand, the larvae web them over. More than one caterpillar may be found in a single fruit. The type of injury is very similar to that done by the larvae of the potato tuber moth, and often it is difficult to determine which species did the damage unless the larva is still present in the fruit. Since a full-grown potato-tuber-moth larva is larger than a mature pinworm larva, large burrows may indicate that the work is that of the former. Yet it is not uncommon for both of these species to be present in the same field.

CONTROL

The control of the tomato pinworm, which is still in the experimental stage, is being conducted by members of the United States Department of Agriculture Bureau of Entomology and Plant Quarantine at Alhambra. They reported that no satisfactory control has been developed, and the methods and materials used against the corn earworm have been only partially successful against the tomato pinworm. At least this is the case where the infestation is heavy. Because the tomato pinworm builds up in large numbers in abandoned fields, they recommended that all plants should be destroyed immediately after harvest, either by plowing or by burning the refuse. Attention was also called to the fact that after harvest, growers often gather the plants and pile them along the edges of the fields or in nearby ravines. From such piles thousands of moths emerge, sometimes continuing for over four months, which makes it possible for adults from a late-fall or winter crop to infest the seed beds or first plantings of the early-spring crop. Needless to say such a practice should be avoided.

Morrill[24] used calcium arsenate dust with some success in checking the infestation of this pest on the west coast of Mexico.

[23] Campbell, R. E., and J. C. Elmore. The tomato pinworm. California State. Dept. Agr. Mo. Bul. 24(3):306. 1935.

[24] Morrill, A. W. Airplane dusting for the control of vegetable pests on the Mexican west coast. Jour. Econ. Ent. 19(5):695–99. 1926.

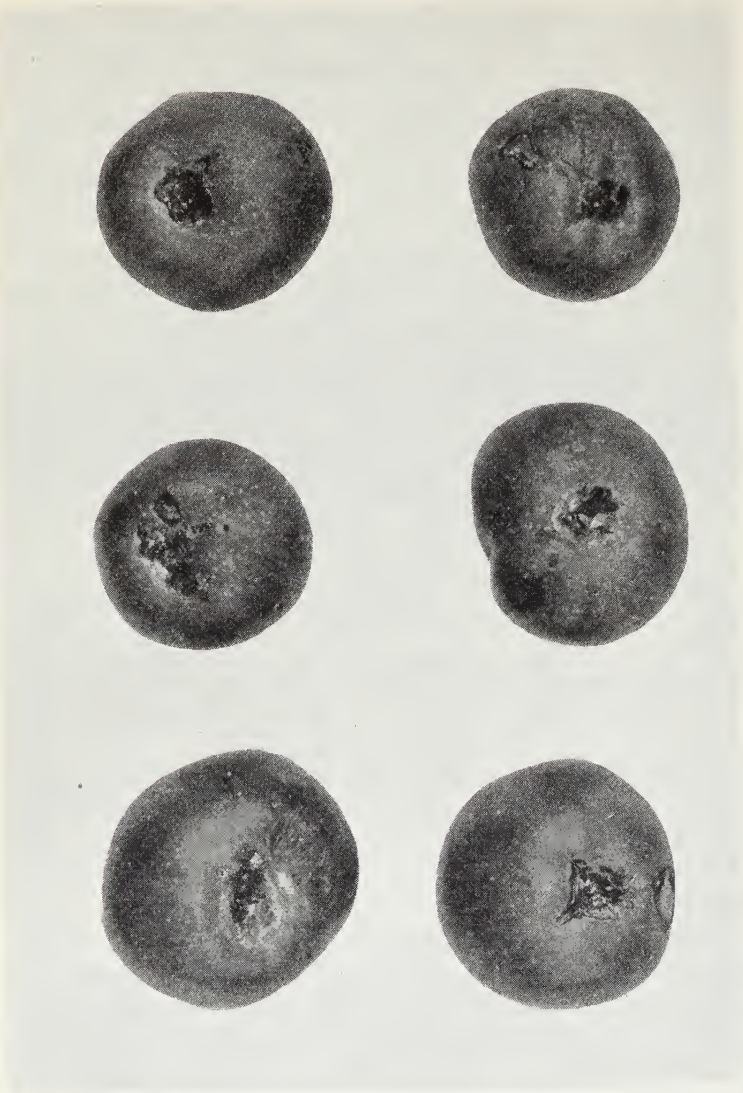


Fig. 8.—Typical external damage to tomatoes by the tomato pinworm. Injury of this type makes the fruit entirely unfit for market. (After Campbell and Elmore, courtesy of California State Department of Agriculture.)

POTATO TUBER MOTH

LIFE HISTORY

The potato tuber moth, *Phthorimaea operculella* (Zeller), also passes through four separate stages. There are several generations a year, and in storage, if food is present and the temperature does not fall too low, breeding occurs throughout the year. The length of a life cycle varies from about one month in the summer to three or more months in the winter. Spencer and Strong[25] gave 25 days as the average time for a

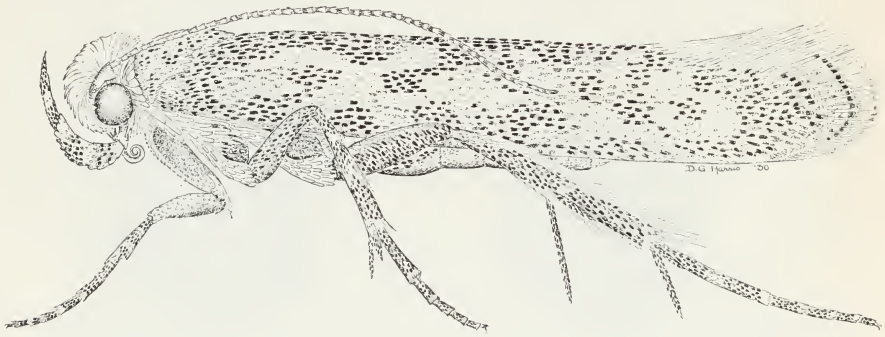


Fig. 9.—The adult potato tuber moth. (After Essig, *A History of Entomology*, by permission of the Macmillan Company, copyright owners.)

generation in summer, and stated that in midsummer adults were reared from eggs laid just 12 days previously, while in the winter they noted that one adult required nearly six months for development. Poos and Peters[26] reported that the period of development from egg to adult varied from 13 days in summer to seven months during the period of lower temperatures. Their data also indicated that the potato tuber moth generally overwintered as full-grown larvae or pupae.

The adults (fig. 9) are small and gray with silvery bodies, and minute dark specks on the fore wings. They are nocturnal. Each female may lay from 150 to 200 eggs, which are small, oval, pearly white and are deposited indiscriminately over the plant. The larvae (fig. 10) molt four times. When full-grown they are generally slightly more than 3/8 inch in length and are either white, yellow, pinkish, or greenish with the head and prothoracic shield dark brown. Pupation occurs in a white silken

[25] Spencer, H., and W. O. Strong. The potato tuber worm. Virginia Truck Exp. Sta. Bul. 53:419–63. 1925.

[26] Poos, F. W., and H. S. Peters. The potato tuber worm. Virginia Truck Exp. Sta. Bul. 61:597–630. 1927.

cocoon in any secluded place, on the host, in the soil, sacks, or the storage bins. We are inclined to believe that in the tomato fields most of the larvae pupate in the surface soil. The pupae (fig. 10) are pale to dark brown in color.

HOST RANGE

The hosts of the potato tuber moth are apparently limited to solanaceous plants including potato, tobacco, tomato, Jimson weed (*Datura stramonium* L.), pepper, horse nettle, eggplant, and nightshade.

Fig. 10.—Larvae and pupae of the potato tuber moth. × 4.

DESTRUCTIVENESS

Tomatoes are subject to attack by the larvae of the potato tuber moth throughout the tomato-growing sections of California. In general it is considered a pest of the fruit, but may attack other parts of the plant as well.

During the 1935 season the infestation was very light and in many fields no injury by this insect was observed. Heaviest infestations were observed where tomatoes followed potatoes. This important relation is considered under "Control" (p. 23). The area of greatest infestation was in the Santa Maria region of Santa Barbara County. Here the damage due to its attacks ranged from about 5 per cent to 57 per cent, with most fields showing less than 10 per cent.

Currier[27] noted that the number of fields in the San Jose area seriously infested with this pest was small, and stated: "Two fields in particular, which should have yielded, at a very conservative estimate, 15 tons of tomatoes, produced only 3 tons which were accepted at the can-

[27] Currier, D. L. Damage to tomatoes by the potato tuber moth (*Phthorimaea operculella* Zeller). California State Dept. Agr. Mo. Bul. 9(3):91. 1920.

nery. Part of these were wormy and had to be sorted." While no damage as serious as the above was observed during the 1935 season, infestations of 5 to 10 per cent were not uncommon.

Because the injured fruit is rather difficult to detect, infestations, even though low, are of considerable annoyance. The larvae prefer to

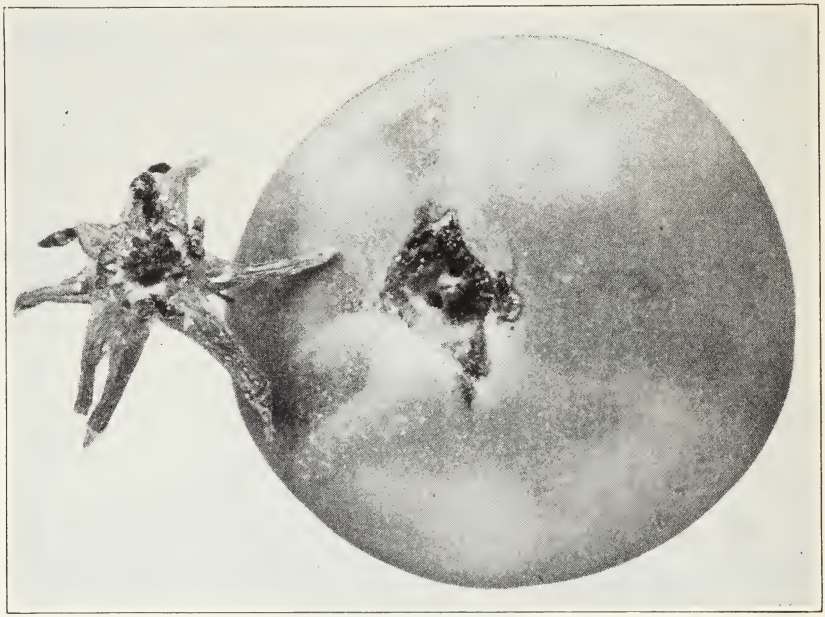


Fig. 11.—Tomato infested at the calyx end by the larva of the potato tuber moth. The calyx has been removed revealing the excrement and entrances to the burrows.

enter the fruit at the calyx end, and seem to be more numerous in those varieties of tomatoes which have firm, solid flesh. When entry is made at the calyx end, the burrows follow the core and the fleshy portions that radiate from it. In the early stages the burrows do not extend far into the fruit, but as the larvae increase in size, they may penetrate deep into the interior. When the calyx is removed, the entrances to the burrows are usually opened (fig. 11). After the fruit has been picked for some little time, however, the larvae close the entrance to their burrows with a webbing and the calyx end of the fruit appears like that shown in figure 12*A*. As this webbing tends to obscure the injury, the fruit must be carefully observed or the damage will pass unnoticed. Figure 12*A* is an enlarged view of the calyx end of a tomato, showing how difficult it is to detect the webbing.

The potato-tuber-moth larvae will also attack the fruit at any place. Where entrance is made at some other point besides the calyx, the larvae

may act as miners and work just below the epidermis as shown in figure 12*B*. They may penetrate deeper into the fruit if they encounter a fleshy part that radiates from the core. When they attack the blossom end, it has been observed that they may penetrate directly into the core.

Several larvae may enter the same fruit, and it has been reported that often fifteen or sixteen worms are found in a single tomato, although it is much more common to find one to three.

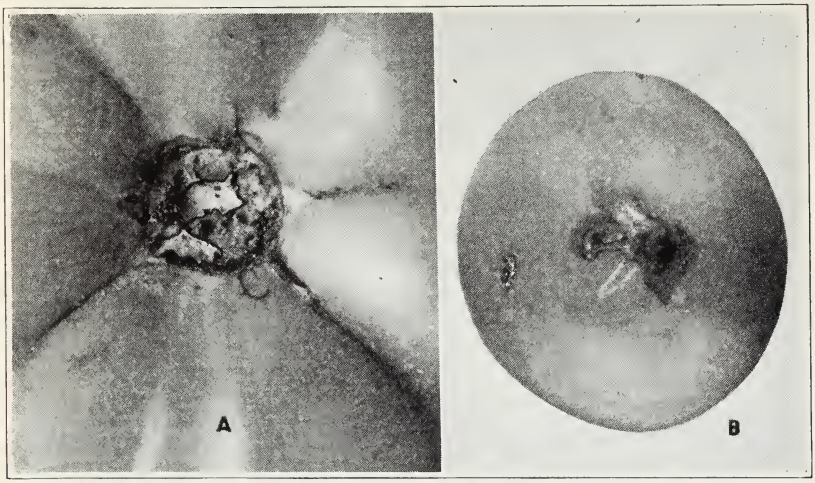


Fig. 12.—Work of the potato tuber moth larvae on tomatoes. *A*, Enlarged view of the calyx end showing the webbing over the burrow entrances; *B*, showing larval mines just below the skin.

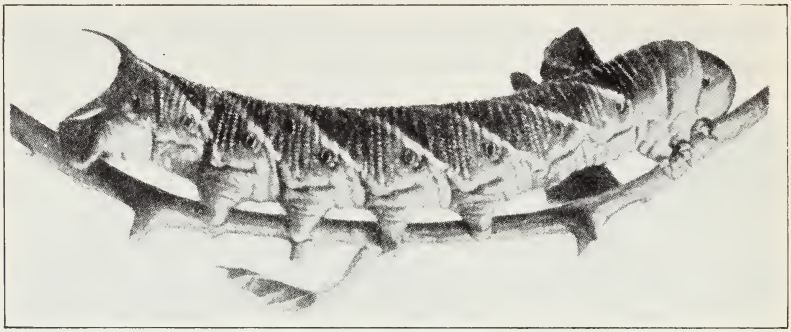
CONTROL

Although the potato tuber moth is known to attack tomatoes in many parts of the world, little work has been undertaken relative to its control on this crop. It appears likely that insecticidal dusts can be used successfully. This possibility will be thoroughly investigated and its control attempted in conjunction with that of the corn earworm.

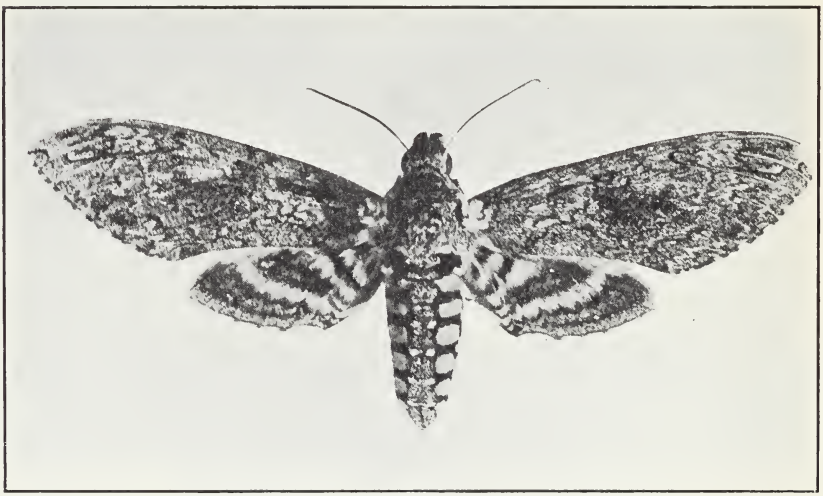
With our present knowledge, it seems certain that proper cultural methods, crop rotation, and the selection of certain tomato varieties may aid considerably in holding the potato tuber moth in check. Since many of the solanaceous plants are probably attacked by the larvae, clean culture is believed to be of considerable value, and land to be planted to tomatoes should be kept free of plants likely to serve as hosts. Where potatoes are being grown, it is undesirable to plant tomatoes, for the latter are almost certain to become infested. Other observations in substantiation of this were also made in Bermuda.[28] Tomatoes should not be

[28] Russell, T. A. Report of the Plant Pathologist. Bermuda Dept. Agr. Rept. 1933:28–36. 1933.

planted where potatoes were grown during the previous year since there is likelihood of enough insects being present on tubers and volunteer potato plants to cause a serious infestation. This has happened in at least two cases which came under our observation during the past season.



A



B

Fig. 13.—The tomato worm: *A*, larva (after Folsom); *B*, adult. (From Ext. Cir. 87.)

In one of the fields the infestation was determined to be 57 per cent, while other fields in the same general area showed worm injury of only 5 to 10 per cent.

Some evidence was obtained which indicated that the Stone or Norton shipping types of tomatoes were more readily attacked than varieties similar to the Santa Clara Canner. In two areas where these types were interplanted, the former were by far the more heavily infested. Some

slight evidence was obtained which seemed to indicate that the more exposed fruit was preferred to that which was well protected by the foliage. If this proves to be the case, luxuriant growing vines should show the lowest relative infestation.

TOMATO WORM AND TOBACCO WORM

Over part of the tomato-growing area of the state the tomato worm, *Protoparce sexta* Joh., and the tobacco worm, *P. quinquemaculata* Haw.,[29] are very destructive to tomatoes. They are considered here because their control, to some degree, can be linked with that of the corn earworm. The

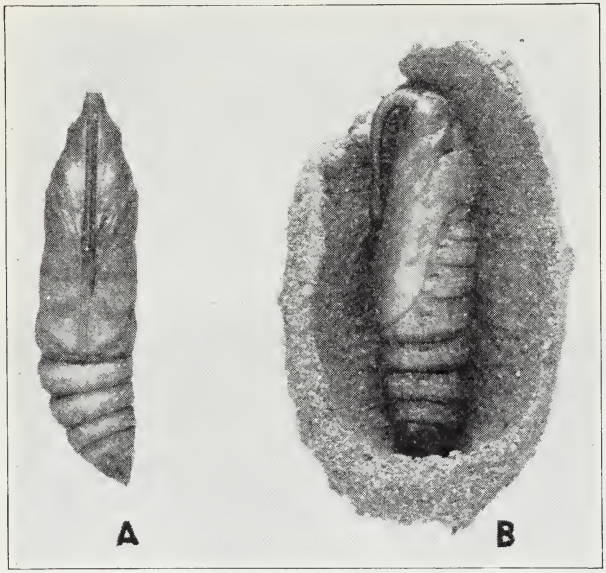


Fig. 14.—*A*, Pupa of the tobacco worm; *B*, pupa of the tomato worm in its cell. The distinguishing character that separates the two species is the sheathed proboscis, which is longer in the tomato worm.

adults of these insects, known as sphinx moths or hummingbird moths, are swift fliers. The larvae (fig. 13*A*) are large green worms, often attaining a length of 4 inches. They strip the leaves from the vines as shown in figure 15. When they are abundant, serious damage may also be done to the developing fruit (fig. 16).

Where plantings are small, the insects can be partially controlled by hand picking and destroying the larvae. During the 1935 season a large field in Riverside County was completely defoliated by these pests, and in the San Joaquin Valley serious damage was done in a number of fields.

[29] The caterpillars of these insects are also commonly called hornworms.

Fig. 15.—Tomato stems that have been nearly defoliated by caterpillars of the tomato worm.

Fig. 16.—Tomato fruits injured by the caterpillars of the tomato worm.

Cryolite dust[30] is very effective against these worms, although our observations show that arsenical and fluosilicate dusts can also be used. As with the corn earworm, these caterpillars should be controlled in the early stages, since after the larvae increase in size they can eat a relatively large amount of poison without being killed. None of the above dusts should be used much after the fruit begins to color. Headlee[31] found that a derris dust was effective against the tomato worm, and, because of the residue problem, it is possible that this material can be satisfactorily used after the applications of other dusts must be discontinued. Unless early control thoroughly checks these pests, we are of the opinion that some insecticide that can be applied during the harvest will not only be desirable but necessary. With this in mind derris will be thoroughly investigated during the coming season.

GENERAL TREATMENT OF THE YOUNG TOMATO PLANTS IN THE FIELDS

TOMATO VINES IN RELATION TO OTHER INSECT PESTS

The previous discussions concerning the treatment of vines has dealt largely with older plants and the protection of the fruit. When the plants are first set out in the field, and before they have started a vigorous growth, they are subject to the attack of several destructive insects, which at times may be so severe as to kill the plants completely. The important enemies in the fields at this season include armyworms, flea beetles, darkling ground beetles, and the vegetable weevil, all of which may be satisfactorily controlled.

Armyworms.—These worms can generally be controlled with poison baits sown about the plants or thinly sprinkled over them. There are many baits that can be used, and the following one has proved satisfactory:

Bran	50 pounds
Molasses	2 quarts
Sodium fluosilicate	2 pounds
Water sufficient to make a nearly dry mash.	

If a field is known to be infested before the plants are set out, it may be advisable to broadcast the bait at the rate of about 15 pounds per acre over the land a few days before planting.

Armyworms may attack the tomato plants during any stage of growth and at times may be destructive to the fruit. The injury caused to the fruit is similar to that done by the corn earworm and can be checked by

[30] Essig, E. O., and W. M. Hoskins. Insects and other pests attacking agricultural crops. California Agr. Ext. Cir. 87:85. 1934.

[31] Headlee, T. J. Derris as an arsenical substitute on vegetables. Jour. Econ. Ent. 28(3):605–7. 1935.

the use of poison baits. There are some armyworms, such as the yellow-striped armyworm, *Prodenia praefica* (Grote), which differ from most cutworms by feeding during the day and usually resting on the plants during the night. Because they remain on the plants, they cannot be satisfactorily controlled with baits scattered on the ground. According to Thompson[32] a calcium arsenate dust (70 per cent tricalcium arsenate), thoroughly mixed with an equal part of hydrated lime, will successfully control them.

Flea Beetles.—These are minute insects (fig. 17*A*) that jump quickly; they cause damage by eating small holes in the leaves. They can be controlled with any of the following dusts: powdered lead arsenate, 1 part to 4 parts of dry lime; or sulfur-nicotine dust and lead arsenate; or with a 70 per cent barium fluosilicate; or a cryolite dust (33 per cent).

A *B*

Fig. 17.—*A*, Adult flea beetles. These insects are very small, and their ability to jump is responsible for the common name. *B*, Adults of the small darkling ground beetle, which often occur in large numbers and severely injure newly transplanted tomatoes. (From Ext. Cir. 87.)

Darkling Ground Beetles.—The beetles, *Blapstinus* spp. (fig. 17*B*) and *Metoponium abnorme* (Lec.), are small—scarcely more than ¼ inch long—and dull black or bluish black. They live in the soil, and are chiefly destructive because they girdle plants. They can be controlled by scattering the following poison bran mash[33] over the ground at planting time:

Bran (or dried ground beet pulp)	25 pounds
Arsenic trioxide	1 pound
Molasses	2 quarts

Mix the arsenic trioxide dry with the bran and add the molasses after diluting somewhat with water. Stir thoroughly and add enough water to make a dry mash which will broadcast easily. The molasses may be omitted without greatly lessening the effectiveness of the bait.

[32] Thompson, B. G. Cutworm control in Oregon. Oregon Agr. Exp. Sta. Cir. 111:1–6. 1935.

[33] Essig, E. O., and W. M. Hoskins. Insects and other pests attacking agricultural crops. California Agr. Ext. Cir. 87:108. 1934.

Dusts, such as 40 per cent barium fluosilicate, give very effective control.

The Vegetable Weevil.—Considerable injury may at times be caused by the vegetable weevil, *Listroderes costirostris* Schoen. (*L. obliquus* Gyll.), shown in figure 18. Lovell reported[34] that for the control of the

Fig. 18.—The adult vegetable weevil, about four times natural size. (From Bul. 546.)

weevil on young plants, a dust of either sodium fluosilicate[35] or barium fluosilicate of 70 per cent to 80 per cent strength can be used. He stated that the dust can best be applied with a knapsack or bellows duster and that a puff or two to each plant, or enough to cover the foliage thoroughly and the ground at the base of the plant, gives protection. The amount needed per acre is 10 to 12 pounds.

[34] Lovell, O. H. The vegetable weevil, *Listroderes obliquus*. California Agr. Exp. Sta. Bul. **546**:1–19. 1932.

[35] In certain of the coastal areas sodium fluosilicate may cause injury to the plants and should therefore be used cautiously.

INSECT VECTORS OF TOMATO DISEASES[36]

Aphids bid fair to become pests of major importance to tomato culture in California. Not only do they produce considerable quantities of honeydew and smutting of the fruit and foliage, as was observed in the case of the potato aphid, *Macrosiphum solanifolii* (Ashmead), in San Diego County last fall, but also certain others such as the green peach aphid, *Myzus persicae* (Sulzer), may prove to be vectors of diseases of the plants.

Thrips are definitely associated with certain diseases. The tobacco or onion thrips, *Thrips tabaci* Lind., the western thrips, *Frankliniella occidentalis* (Perg.), and Moulton's thrips, *F. moultoni* Hood, are all capable of transmitting tomato spotted wilt[37] in California.

The beet leafhopper, *Eutettix tenellus* (Baker), is a vector of tomato curly top (western tomato blight), which is an important disease of tomatoes in certain portions of the state where this insect occurs.

An obscure disease known as psyllid yellows[38] is connected with the common tomato psyllid, *Paratrioza cockerelli* Sulc. It affects both the tomato and the potato and occurs in several of the western states including California.

METHODS OF APPLYING DUSTS

Dusts can be applied either with hand machines, horse-drawn dusters, power dusters, or by airplanes. It is best to apply the dust on still days, when the vines are slightly wet with dew. The method used will probably be influenced by the equipment the grower has available. For the dusting to be most effective, the vines should be evenly and thoroughly covered with the insecticide.

There are certain areas where power dusters and airplanes can be used. If the latter are used, certain precautions should be followed. The dust should be applied to that crop to be protected and not on surrounding fields. If there is danger of drift, the dusting should be postponed or some other method of application used. Such care is necessary, since

[36] These insects are barely mentioned here to call attention to the fact that the investigations of tomato insects and their control involves more than the well-known worms that attack the fruit, and to point out the fact that we are interested in the problem in its broadest aspect.

[37] Gardner, M. W., and O. C. Whipple. Spotted wilt of tomatoes and its transmission. Phytopathology 24:1136. 1934. Also: Gardner, M. W., C. M. Tompkins, and O. C. Whipple. Spotted wilt of truck crops and ornamental plants. Phytopathology 25:17. 1935. And: Bailey, S. F. Thrips as vectors of plant disease. Jour. Econ. Ent. 28(6)856–63. 1935.

[38] Binkley, A. M. Transmission studies with the new psyllid yellows, disease of solanaceous plants. Science (n.s.) 70:615. 1929.

indiscriminate applications of poison dusts are likely to cause litigation should they result in the poisoning of bees and livestock, or cause others loss in any way. Also, for a dust to be efficient, it should be concentrated on the crop to be protected and not thinly scattered over larger areas.

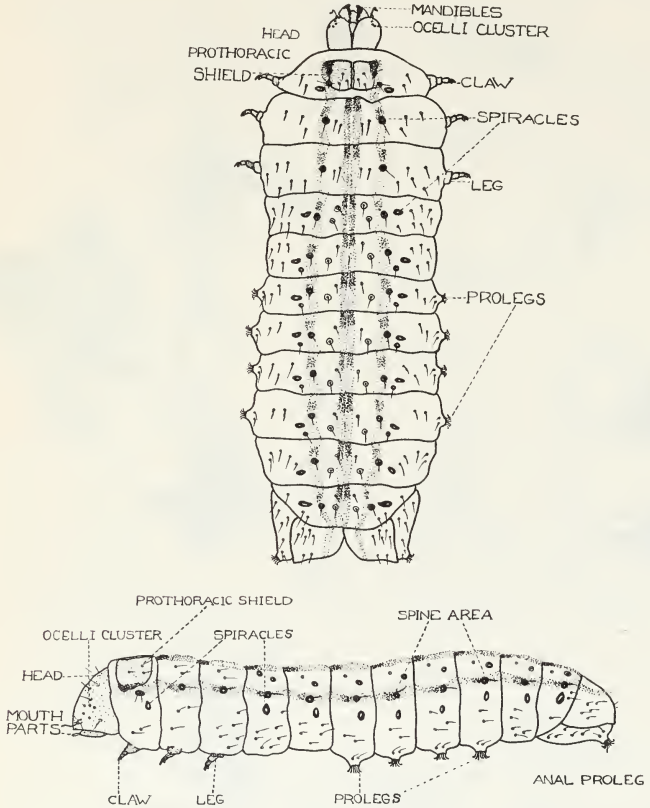


Fig. 19.—The corn earworm. The skin of a full-grown caterpillar cleared and slit down the venter to show the various anatomical parts from the dorsum, at the top. A side view, at the bottom. All greatly enlarged.

Where the acreage is large, airplanes have been successfully used. To get good coverage, the planes must fly close to the tops of the vines.

If the grower wishes, a lead arsenate spray, 3 pounds to 100 gallons of water containing a spreader, can be used instead of a dust, if applied not later than the time the fruit is setting.

Caution.—Since the control of tomato pests calls for the use of insecticides that are poisonous to men and animals, care should always be used in applying them. This is particularly true where poison baits are used, for if chickens or children are present, there is danger of their

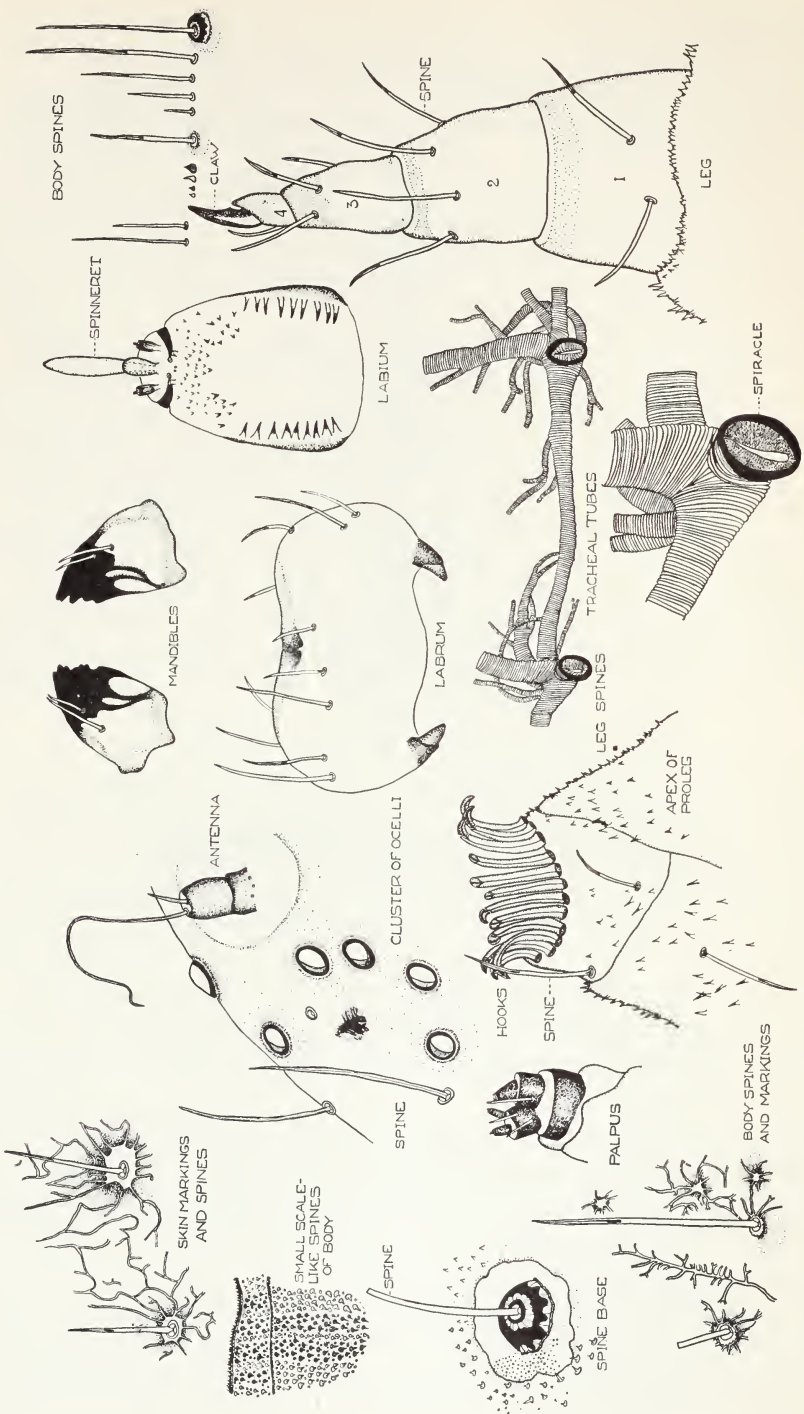


Fig. 20.—The corn earworm. Various anatomical parts, greatly enlarged.

eating it, which might result in serious consequences. Cattle or other animals should be kept away from freshly dusted fields. *Attention has repeatedly been called to the inadvisability of applying poisonous insecticides to the plants after the fruit begins to color.*

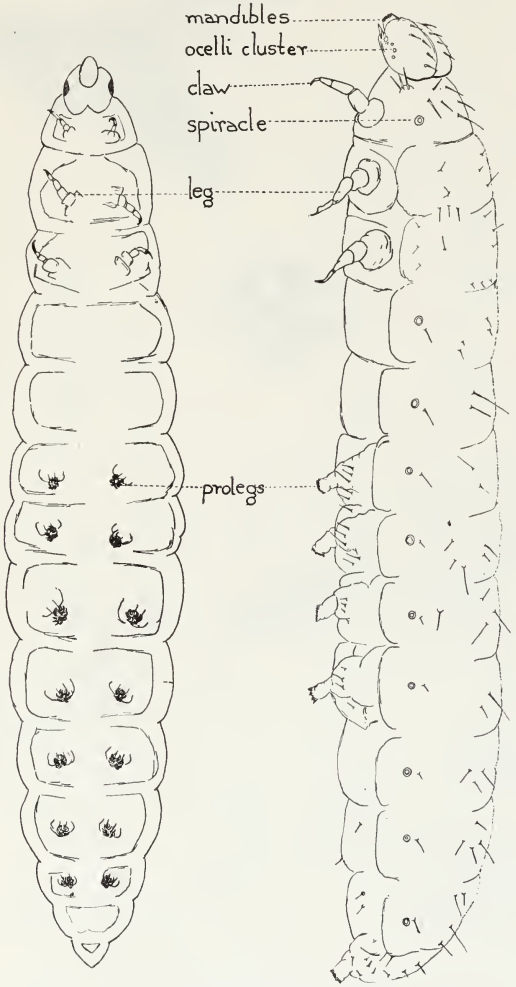


Fig. 21.—Caterpillar of the tomato pinworm drawn from the ventral (left) and lateral (right) aspects. Greatly enlarged.

INSECT PARTS IN PREPARED TOMATO PRODUCTS

The discovery of considerable numbers of insect parts in prepared tomato products is one of the chief reasons for the investigations discussed in this circular and particularly for the control of the insects which feed on the fruits of the tomato. The caterpillars of the corn earworm, other

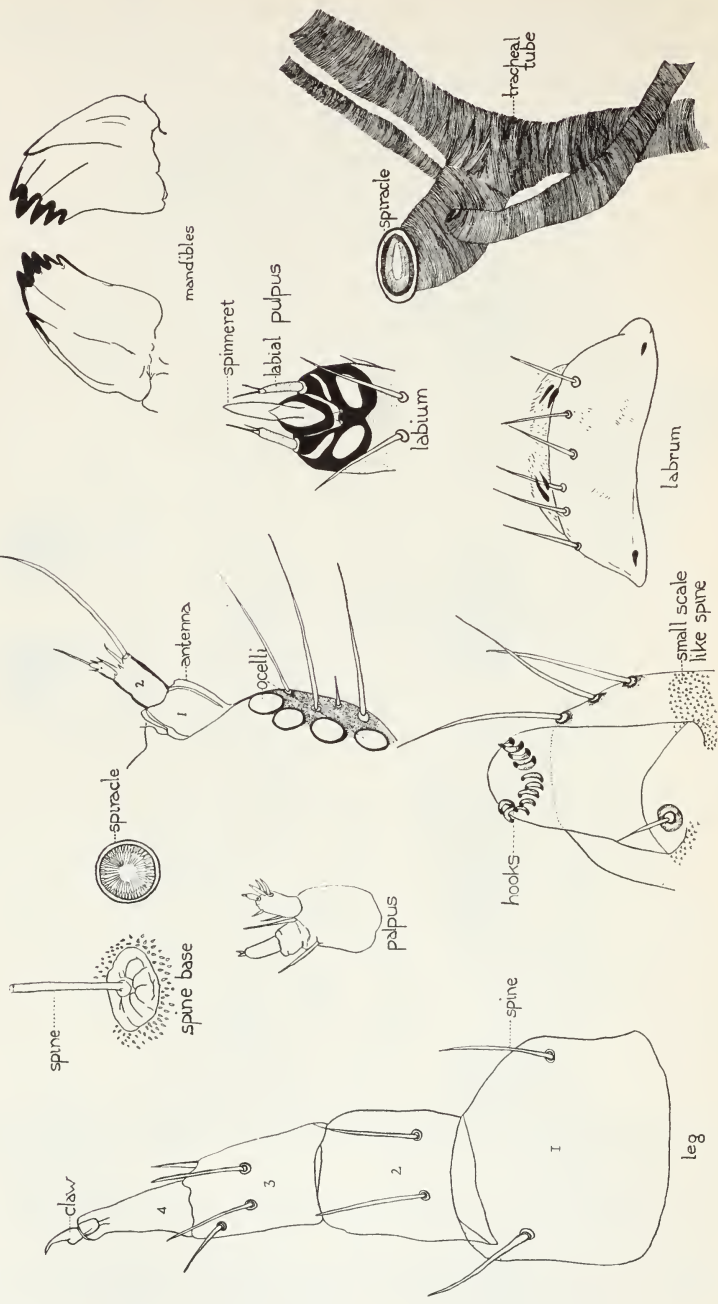


Fig. 22.—The tomato pinworm. Various anatomical parts of the caterpillar greatly enlarged.

cutworms, tomato pinworm, potato tuber moth, and their parasites, commonly occur in the fruit at the time of harvest. Not only are the living forms present, but also often the molted skins which remain in the bur-

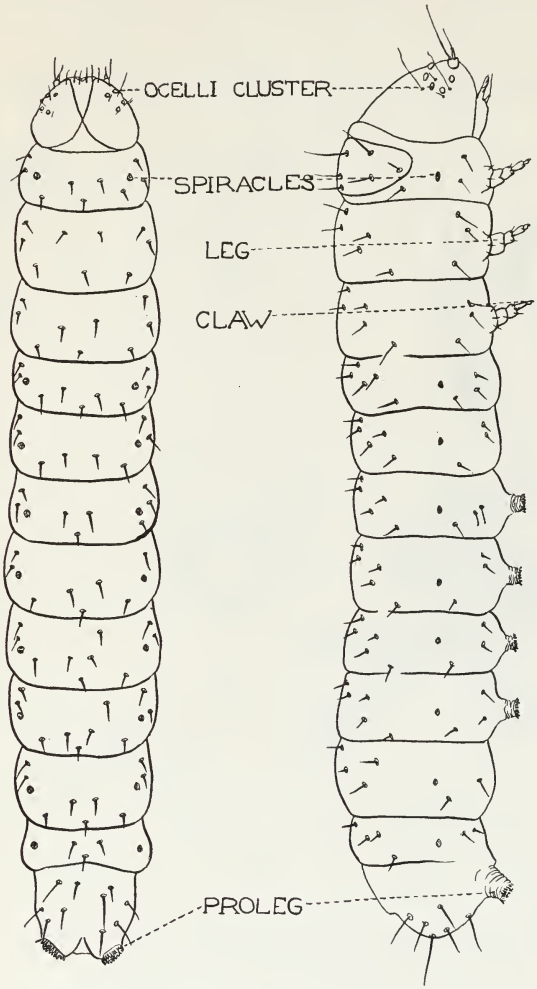


Fig. 23.—Caterpillar of the potato tuber moth drawn from the dorsal (left) and lateral (right) aspects. Greatly enlarged.

rows. In canning, preserving, and other processes in the preparation of food products, these insects and their cast skins may be divided into innumerable minute pieces not discernible to the unaided eye. They are easily detected by a method which involves the shaking of a small quantity of the tomato product with gasoline and water. The insect parts come to the surface and may be removed and examined with a microscope.

Naturally, one not familiar with the various anatomical parts would be totally unable to distinguish the species of insects involved. In order to assist in this rather difficult examination we have prepared special illustrations showing the caterpillars of the three important insects: the corn

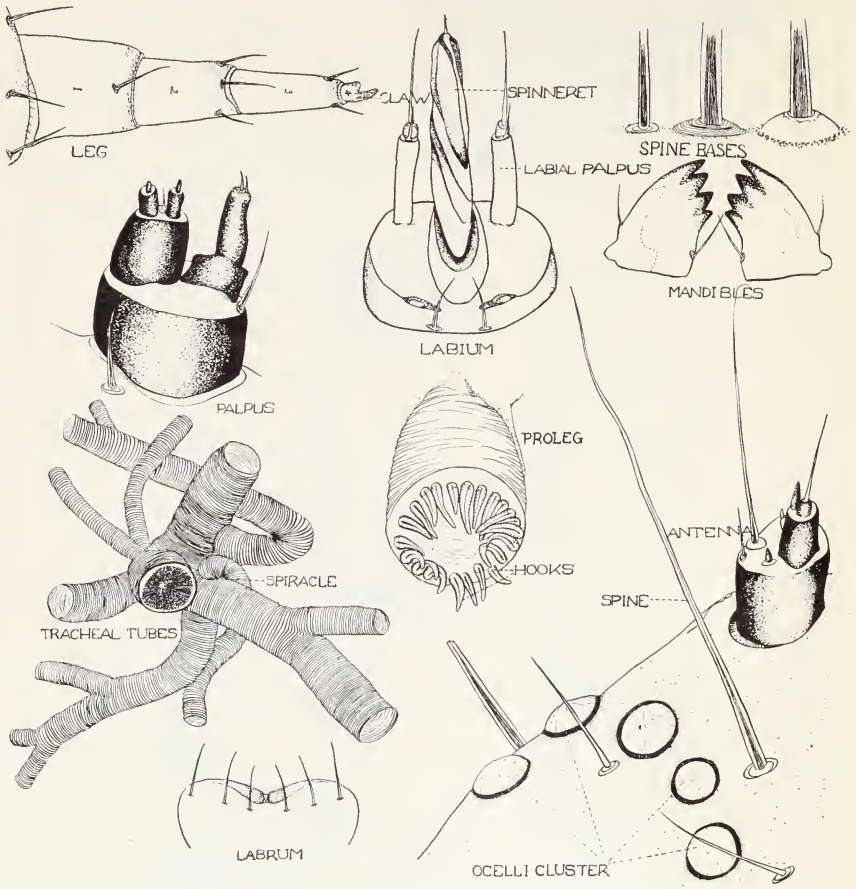


Fig. 24.—The potato tuber moth. Various anatomical parts of the caterpillar greatly enlarged.

earworm (figs. 19 and 20);[39] the tomato pinworm (figs. 21 and 22); and the potato tuber moth (figs. 23 and 24). If these drawings are examined carefully, it will be seen that many of the anatomical characters are sufficiently different to distinguish beyond doubt the exact insects that may be found. With this aid available it will then enable investigators to direct control measures to rid the tomato fields of the pests responsible for the contamination.

[39] These drawings were made with the aid of National Youth Administration and Public Works Administration funds.

SUMMARY

The more important pests of tomato vines and fruit are: corn earworm, tomato pinworm, potato tuber moth, tomato worm, tobacco worm, many different species of noctuid moths, several beetles, thrips, aphids, and leafhoppers.

Under California conditions there are at least three generations of the corn earworm; the winter is passed in the pupal stage in the soil. The larvae have an extended host range, and are particularly injurious to such plants as corn, cotton, tomatoes, and tobacco. Where severe, as much as 50 per cent of the tomato crop may be ruined, although a survey during the 1935 season showed no injury as high as this. Large areas were found where the infestation was low.

For corn-earworm control, fall or winter plowing is desirable because many pupae are exposed to the weather and their natural enemies. Their emergence burrows are also destroyed or filled up, which makes it difficult for the moths to escape. There is some debate concerning the value of planting corn as a trap crop, and for California conditions further study is much needed. If corn is used, to be successful it should be in the tassel to silking stage during the period the tomatoes are in most need of protection. To insure this, sweet corn should be planted in solid blocks two or three times at intervals of about two weeks and harvested before the worms have matured and dropped to the ground to pupate.

Where calcium arsenate is used, it may be applied undiluted at the rate of 10 to 15 pounds per acre. Lead arsenate should be diluted with lime in the proportion of 1 to 1 and applied at the rate of 10 to 20 pounds per acre. The fluosilicate dust or synthetic cryolite should be diluted to from 40 to 60 per cent and according to the size of the plants applied at the rate of 20 to 30 pounds per acre. If the infestation is light, a single dusting at the time the fruit is setting may be sufficient. If heavy, subsequent dustings will probably be necessary, but because of the residue problem it may be inadvisable to use arsenicals or fluosilicates much after the fruit begins to color.

The tomato pinworm passes through several generations a year and hibernates and passes through periods of low temperatures in the pupal stage. It attacks the vines, but is principally important as a pest of the fruit. The larvae prefer to enter at the calyx end and may injure 50 per cent or more of the fruit. Even where the infestation is light, it is of considerable annoyance, since the damage caused to the fruit is relatively hard to detect. Dusts used against the corn earworm are not wholly

satisfactory against this pest. Destruction of the tomato vines as soon as harvest is complete is highly recommended. So far we have found no injury due to this insect in central and northern California.

The potato tuber moth passes through several generations each year, and if food and temperature conditions are favorable will continue to breed throughout the winter. Where the temperature falls below the developmental zero, it passes the winter as a mature larva or pupa. The injury which it causes to the tomato fruit is somewhat similar to that caused by the pinworm. The potato tuber moth is widely distributed throughout the tomato-growing area of the state, but the infestation is not generally heavy. Severe damage can be expected where tomatoes follow potatoes; therefore, this practice should be avoided. Also apparently the Stone or Norton shipping types of tomato are more severely injured than the Santa Clara Canner type.

The tomato and tobacco worms are very destructive in parts of the state. A cryolite dust is very effective against them, but cannot be used much after the fruit begins to color because of the residue problem. Work with derris dusts as a substitute for later dustings will be carried out during the coming year.

Dusting equipment should be of such a type that the dusts will be evenly and thoroughly applied. Where airplanes are used, caution should be exercised to see that the dusts are not indiscriminately applied and allowed to drift into other fields.

Poison baits can be effectively used against armyworms, with the exception of certain species such as the yellow-striped armyworm for which a dust must be used.

Flea beetles and the vegetable weevil may at times be very destructive, but poison dusts can be applied that will satisfactorily control them.

Darkling ground beetles, which at times are very destructive to young plants, can be controlled with a poison bait or a 40 per cent fluosilicate dust.

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